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GEOPHYSICAL VARIABLES AND BEHAVIOR: LXVI. GEOMAGNETIC STORM SUDDEN COMMENCEMENTS AND COMMERCIAL AIRCRASHES [1]

M. A. PERSINGER

Laurentian University

Summary.—The hypothesis that sudden commencements of global geomagnetic activity ("sudden impulses") could induce anomalous changes in onboard computers and facilitate commercial aircrashes was investigated. During the years 1988 and 1989 the mean daily occurrence of a commercial disaster somewhere in the world increased from 0.06 to 0.12 within 24 hr. of a sudden commencement. When numbers of sudden commencements per month were correlated with eight major categories of catastrophes (including air disasters) only aircrashes, primarily occurring during maximum computer-dependent flight conditions, were significantly correlated (.54) with numbers of sudden commencements but not with average monthly geomagnetic (aa) activity.

Computer systems have become so extensive within modern commercial aviation that during critical adverse weather conditions, the pilot and passengers are totally dependent upon electronic systems. Because the ultimate information to which the pilot attends is effectively a complicated series of 0,1 statements within the computer circuitry, anomalous inductions within onboard computer systems could alter the information and the pilot's decision. One type of geomagnetic phenomena, the "sudden impulse" or sudden storm commencement (ssc or sc), is associated with an increase of between 10 and 100 nT within 100 to 500 seconds (Mayaud, 1975); it has the capacity to induce current within these systems at "decision" nodes because the rate of change in current amplitude over time is within the range of the less stable direct current (d.c.)/alternating current (a.c.) interface.

The present analyses were designed to discern whether airplane crashes were more likely to occur during the periods of sudden commencements of increased geomagnetic activity. Commercial catastrophes were utilized because of (1) the public documentation and (2) the propensity for large onboard computer systems. The latter condition satisfied the theoretical assumptions that the more complicated the electronic decision-making process, the smaller the induction anomaly required to induce catastrophic errors within the system.

The dates for all major airplane crashes during the years 1988 and 1989 were obtained from the *Book of the Year* volumes of the *Encyclopedia Bri-*

[1]Send correspondence to Dr. M. A. Persinger, Behavioral Neuroscience Laboratory, Department of Psychology, Laurentian University, Sudbury, Ontario, Canada P3E 2C6.

tannica; these years were selected because they include the peak in solar cycle 22 and hence should be associated with frequent sudden commencements; during these 731 successive days 67 days involved at least one sudden storm commencement (verified alerts from Boulder, Colorado). The numbers of days in which air disasters had occurred were designated as total ($n = 65$) and those that did not involve military, suspected terrorist, or clear mechanical failures; the latter (47), most of which involved crashes during adverse weather conditions, were designated as criterion crashes and were considered maximum tests of the hypothesis. To ensure the specificity of any effect to air disasters all of the events (for which specific dates were given) for the following categories were also collected (numbers of event days in parentheses): fire (26), marine (38), mining (15), miscellaneous (23), natural (65), railroad (27), and traffic, (27).

There were two temporal increments of analyses, daily and monthly; for the latter, the total numbers of sudden commencements and catastrophes for each of the categories were summed per month. For the daily analyses the mean numbers of events within ± 1 day of sudden commencements were calculated for each catastrophe category. This was completed because of the unknown time-zone discrepancies between the catastrophes and the sudden commencements. For the monthly analyses bivariate correlations (Pearson) were completed between the total numbers of sudden commencement days per month or the mean amplitude (in gamma) per impulse and each of the catastrophe categories. To control for the possibility that any correlation with numbers of sudden commencement was confounded by general increases in geomagnetic activity, monthly aa values were also obtained from the *Geomagnetic Indices Bulletin* (Boulder) and used as covariates for partial correlation analyses. All analyses were completed with SPSS^x software on a VAX 4000 computer.

The mean numbers of criterion aircrash days for days with sudden commencements were 0.12 but 0.06 for days with no sudden commencements ($F_{1,728} = 10.72$; $\chi^2 = 11.57$, $p < .001$); these values for all aircrash days were 0.14 and 0.08 ($F_{1,728} = 8.08$; $\chi^2 = 8.79$, $p < .01$); the effects were equivalent to correlation coefficients of about 0.11. There was no statistically significant difference between days with sudden commencements and no sudden commencements for the occurrence of events in the other catastrophe categories. Step-wise multiple regression verified the aircrash-specific results.

Monthly ($n = 24$) analyses indicated a statistically significant ($p < .01$) Pearson correlation of 0.54 between the numbers of criterion aircrashes per month ($M = 2.0$, range = 0 through 5) and the numbers of sudden commencements per month ($M = 2.8$, range = 0 through 7); for all aircrashes ($M = 2.7$, range = 0 through 6) this value approached significance (0.36; $.05 < p < .10$). The correlation between criterion aircrashes and monthly aa averages was

not significant ($r = .26$) while the correlation between these values and numbers of sudden commencements per month was significant [$r = 0.52$; Mayaud (1975) indicates $r = 0.58$ over 100 years]. There were no statistically significant correlations between numbers of sudden commencements per month and fire, marine, mining, miscellaneous, natural, railroad or traffic catastrophes. The mean amplitude of the sudden commencements per month was not correlated significantly with any of the categories including the air disasters. The partial correlation between the numbers of criterion aircrashes per month and sudden commencements after the monthly aa values had been controlled was 0.58 ($p < .01$). When sudden commencements were held constant, the correlation between monthly aa values and numbers of criterion aircrashes was −0.25 (ns).

These results indicate that the risk of aircrashes during conditions that require total dependence upon onboard computer and electronic systems increases during the months in which sudden (geomagnetic) commencements occur. The specificity of the effect to aviation systems is suggested by the absence of significant correlation with other categories of catastrophe. Because (1) there was only a weak daily effect of sudden commencement occurrence upon aircrashes, (2) they were not correlated specifically with the amplitude of the sudden commencements per month, and (3) mean general geomagnetic perturbation (aa activity) was not correlated with the aircrashes, there is likely to be a statistical pattern of current induction (increasing linearly with numbers of sudden commencements/month) that facilitates electronic disruptions in aviation systems. Comparison of the disruptions to possible sequelae of lightning strikes is not appropriate because the sudden commencement-induced changes would distort the information rather than disable the electronic operation. This becomes important only when total dependence is placed on those systems. It should be emphasized that the risk of air disaster, considering the numbers of commercial flights per day, is minuscule even during sudden commencements.

REFERENCE

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